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Dept Report 45

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OF

AMERICAN AGRICULTURAL COLLEGES

AND

EXPERIMENT STATIONS.

CONVENTION HELD AT THE DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C., OCTOBER, 1887.

REPORT OF THE COMMITTEE ON STATION WORK.

W. O. ATWATER, PH. D., Middletown, Conn.,
S. W. JOHNSON, PH. D., New Haven, Conn.,
GEO. H. COOK, LL. D., New Brunswick, N. J.,
Committee.

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INTRODUCTION.

The committee, appointed in accordance with a resolution passed near the close of the last session of the convention, respectfully present the following statements:

I.

The resolution was somewhat general in its character, and in order to learn as definitely as practicable what was expected of them the committee availed themselves of such opportunity as they could find, after the close of the meeting, to converse personally with members of the convention. From the resolution, the discussion, personal conference, and letters of inquiry, they gather that they were desired in general to consider and suggest how the work of the stations can be planned, co-ordinated, and otherwise facilitated, so as to secure the greatest efficiency in the carrying out of their purpose as specified in the Congressional enactment, and, in particular and immediately, to collate information and make suggestions as to—

Material equipment of stations, including especially buildings, apparatus, books, etc.
Lines and methods of individual and co-operative investigation by the stations.
Intercommunication between the stations.
Means of obtaining accounts of the operations and results of work of experiment stations and other institutions for agricultural research, American and European.
Methods of disseminating information as to stations and station work among farmers, and securing their co-operation.

All that the committee can do in the brief time allowed before the publication of the present report is to make a few statements and suggestions concerning the more important points, and these only in outline. In so doing they are aware that their duty is simply to inquire and to suggest.

As regards the material equipment of the stations it is difficult to make general recommendations, because of the diversity of the work of the stations and of the conditions under which it is to be done.

At the request of the convention, one of the members of the committee has prepared a list of books appropriate to a station library. This is printed elsewhere. Apparatus will naturally be suited to the demands of each case. The facilities now offered by dealers for importing European apparatus duty free make this way of economizing in the purchase very convenient. Examples of buildings erected on plans which are the outcome of experience in station work are to be seen at the Massachusetts station in Amherst and the Connecticut station in New Haven. The North Carolina station at Raleigh has a greenhouse and connected arrangements for vegetation experiments, the plans for which were, with minor modifications, as prepared for the Connecticut station in anticipation of a structure for the purpose there. The New Jersey station at Rutgers College, New Brunswick, gives an illustration of what can be done with small existing accommodations.

Descriptions of buildings, apparatus, greenhouses, grounds, and other things belonging to the material equipment of stations are to be found in the journals and memoirs which contain the original reports of their work. There are a few special volumes which are very convenient for reference in this connection; such, for instance, is Professor Grandeau's Stations Agronomiques, Paris, 1869, which gives descriptions of some German experiment stations.

To give detailed plans for laboratory buildings to be put up at a given cost, or ways in which a given amount of money could be spent for apparatus, has been requested in letters received by the committee. In the lack of definite information it would be a difficult task at best, and with the limited time at the disposal of the committee it is hardly practicable to make in this report any series of general outlines which would be worth enough to warrant the attempt. The committee will, however, be very glad to do anything in their power in response to individual inquiries.

Concerning means for intercommunication between the stations, the committee feel delicate about making suggestions, the more so as the matter has been discussed at conventions, and especially as the authority given the Commissioner of Agriculture by Congress in the Hatch bill would seem to include measures to this end, and the Commissioner has signified his intention to make provision which may include this. They will, therefore, only say that both their observation of the workings of other stations and their own personal experience have impressed them with the importance of full and frequent intercommunication, in order that each station may be made constantly acquainted with the work of others, and that conference and consultations may be facilitated. One of the difficulties under which the workers of the stations must labor is their comparative remoteness from each other and the consequent lack of that constant contact which is so helpful. Whatever will tend to bring them together, and to keep them in the great current of experimental research, will be of the utmost usefulness. Both meetings for discussion of special topics of interest and an interchange of publications will be most valuable. It might be well for each station, carrying out liberally the principle of the law of 1862, to send several copies of each of its publications to each of the other stations.

Doubtless one very efficient agency would be an organ of the stations, a publication which should contain accounts of their current research, abstracts of like work in other countries, and other matters of mutual interest. Such a publication, properly edited and adapted to our special wants, appearing regularly and bringing the latest information, doing for workers in that special line what the *Die Landwirthschaftlichen Versuch-Stationen* does for the German stations, and the journal of the London Chemical Society does for chemists in general, and otherwise providing prompt and constant intercommunication between individual stations and bringing to them things they want to know from outside, would be extremely valuable. Of course it would cost no little labor, learning, and money, but with the particularly pressing need of every help of this sort, the expense would bear no comparison with the usefulness; indeed, it is a question whether the stations can afford to be without it.

The methods of disseminating information are likewise a matter concerning which the committee feel some delicacy in making suggestions, except in so far as to say that from their individual experience as station directors, and what they have otherwise observed, they are led to believe that each station will serve its constituency, the cause, and its own interests by setting forth in reports, bulletins, lectures before farmers' meetings, and otherwise the fruits of its own and other work in the forms best adapted to the purpose.

It is the duty of the station to educate as well as to investigate. It can make its own product more useful to its community by adding to it what has been elsewhere obtained, but its announcements should be only those of accurately attested fact; any others will weaken its influence. For reports of researches technical forms are in place, but statements of practical results for farmers' use ought to be in plain, terse language, and accompanied by such explanations that the people for whom they are intended will easily understand and not mistake their meaning.

Among the means for securing the co-operation of the farmers, and at the same time acquiring and disseminating useful information, one of the most useful and efficient with which the committee are familiar is that of instituting experiments by agricultural associations and individual farmers. As stated beyond, the committee are endeavoring, by correspondence and the preparation of a brief report on this especial subject, to facilitate co-operative effort in this direction the coming season.

II.

One of the things most frequently insisted upon in the convention and elsewhere is the importance of learning what questions especially demand attention in the different States or sections, to what extent these questions have already been investigated, and in what ways the different stations may advantageously avoid repeating work which has already been done, or is to be done, by other stations, or may co-operate in the study of problems of common interest.

In order to obtain information as to the subjects which the different stations would naturally be called upon to study, and at the same time secure the benefit of the suggestions which might be made by gentlemen who are charged with the work, the committee have sent out circulars of inquiry to representatives of stations and colleges concerned in one or both of the acts of Congress of 1862 and 1887. As the association had made provisions by which other institutions engaged in agricultural experimenting might participate in its work the circulars were sent to a number of these also. Replies have been received from a large number of the stations. Some are quite extended, and include details which would be hardly in place in this report; others are very brief. The replies are still coming at the time of this writing. The committee are sorry not to have replies from all in season to include them here. The omissions and slight editorial alterations made in putting the communications into shape for the printer have not been made without care, and the committee hope that if in any case they shall appear to the writer to have left out matter of importance, or otherwise done injustice to the communication, he will at least have the charity to believe that the committee have done no intentional wrong.

REPLIES TO CIRCULAR.

Professor Jordan, director of the Maine Agricultural Experiment Station, maps out divisions of work of investigations, etc., as follows:

(1) Fertilizers, plant nutrition, methods of crop-growing.
(2) Foods, feeding, animal products.
(3) Plants, their diseases, injurious insects.
(4) Diseases of animals.
(5) Horticultural work.
(6) Agricultural physics and meteorology.
(7) Police work (fertilizer control, etc.).

Among the special questions which will demand the attention of the Maine Station Professor Jordan mentions as one of the first, "The economic side of compoundings of cattle rations, around which general questions are grouped a number of minor problems." For buildings, he now hopes for the erection, at the outset, of one to serve principally for the chemical work in which would be the station office and the director's private room. Later, if funds are forthcoming, a horticultural outfit in connection with a building which shall also accommodate natural history and veterinary work will be desired. Professor Jordan suggests that intercommunication between the stations will be facilitated by personal correspondence between those interested in similar lines of research, and the general good would be advanced if the results obtained by all the stations could be digested and put into convenient form for publication by proper persons. One of the methods proposed and since undertaken by the Maine Station for putting itself in connection with its constituency is a canvass of the whole State for names of farmers who are desirous of receiving bulletins.

Professor Whitcher, of the New Hampshire College of Agriculture and the Mechanic Arts, considers that in that State "the dairy interest is all important, and opens the door to numerous lines of study." As this State is so far north the question of the success of new Russian forage crops is a matter of interest, and the ensilage problem is very important. In connection with the production of these crops come the questions of soil fertility and its maintenance by manures.

Professor Whitcher lays out an interesting scheme of questions connected with and emanating from the general one of dairying. They include breeds of cattle; crops for fodder, and the fertilizing of land for their production; waste products for fodder; milk, and how it is affected by food, abnormal condition of animals, breed, and surroundings; cheese and butter, and their manufacture, etc. Included under these are various minor problems. Among these latter, Professor Whitcher mentions particularly "The laws which govern the effect of food upon milk, if such laws exist or are discoverable; the physical properties of milk and cream; the solution of the vexing milk-globule problem; the why and wherefore of churning; the clearing up of the so-called ripening of cream; the part played by micro-organisms, etc." Professor Whitcher's plan would, if carried out, make the New Hampshire Station, to a considerable extent, a splendid dairy station.

From Vermont, Mr. W. W. Cooke, director of the State Agricultural Experiment Station, writes that—

> Feeding and fertilizers are the most prominent questions that our farmers are desirous of having the station take in hand. Some of the questions they are asking are as follows:
>
> To what extent can cotton-seed meal be profitably substituted for corn meal in the production of butter?
>
> Can Holsteins be profitably used as butter cows in Vermont?
>
> Can undissolved phosphates be profitably used on the farm for any crop? What can we afford to pay for Thomas slag?
>
> Is there a method for determining what is lacking in the soil more accurate than plot experiments?
>
> What is the cause and what the cure of potato scab; and what of potato rot? What will cure rust in oats? What is the remedy for pear blight?

Mr. Cooke thinks a good deal of the work of the Vermont Station will be in the line of the diseases of plants. His letter suggests a number of other questions, the chief of which are the feasibility of judging of the needs of a soil from the analysis of the ash of the plants that grow upon it; the effect of nitrogenous and phosphatic fertilizers upon the digestibility of the protein of a fodder; the value of the increased amount of digestible protein derived from an acre of timothy that has been manured with nitrogenous fertilizers as compared with the cost of the fertilizer, "*i. e.*, how much extra fertilizer can be profitably applied for this particular purpose?"

Mr. Cooke would deem it wise for the stations in some of their earlier bulletins to give a general sketch of the problems they are to work on during the coming season, adding that "I think each would furnish food for reflection for many of the other stations."

From the University of Wisconsin, Prof. W. A. Henry, director of the Agricultural Experiment Station of that State, sends the following:

> Questions uppermost in our minds here are:
>
> (1) The effects of the various food articles upon the composition of the body of the animal fed. Under this is the question of whether or not protein from milk will build up the same sort of frame as protein from shorts, pease, or clover. In other words, is protein protein, no matter what the source? Another question of interest in this part is, "Does not excessive corn feeding greatly weaken the bones of animals from lack of mineral matter in the food supply?"

> (2) The best method of housing fodder and preparing it for feeding to stock. Under this comes the subject of ensilage, with its many problems, to which the station is directing most of its money and energy this year. There are not less than 700 silos in the State, and many more will be built the coming season. We are much pressed for information on the subject by our farmers. While most of the work is in the directly practical line, we are carrying on a carefully planned digestion experiment with ensilage and fodder, thus trying to add to our very limited knowledge on that side of the subject.
>
> We are also studying the cutting of feed and grinding and cooking of grain.
>
> (3) We hope, now that Dr. Babcock is with us, to make a careful study of the physical proportions of milk. This most important question has been almost neglected thus far. Our second chemist is patiently working on the test churn and hunting for a quick, simple method of determining the fat in milk so that patrons in co-operative dairy factories can divide money on milk according to quantity multiplied by quality as indicated by the fat content. This is a very important question in this State where the dairy interests are very large and co-operation the rule.
>
> (4) We have done nothing, nor do we wish to have much to do, with commercial fertilizers. We shall labor to keep them out of the State by conserving the fertility of our soil. What we need of additional fertility we propose to import from Dakota and Manitoba in the form of bran and shorts. This station has for years labored with our farmers on this point, and now train-loads of bran are left daily in our State to be fed to our stock, the manure from which feeds the land.
>
> (5) Soil physics and soil fertility we should take up, and hope to do so under the new régime.

As regards co-operation between different stations, Professor Henry thinks that the most reasonable way at present "would be to let the various stations fall into lines of work of common interest by natural affinity rather than by forced union or co-operation. Individuality is a factor of great power in all good work, as shown by our American stations as well as foreign ones. I have really no fear of the useless duplication of work that is sometimes mentioned in this connection. That we ought to combine the work together I fully believe, but let this combination come about from a feeling of necessity." Professor Henry thinks representatives of different stations interested in a given subject will naturally communicate with one another, and arrange for work which may be to a greater or less extent co-operative, and adds:

> Let us come together often, and listen to the leaders of thought in the various lines and to our committees, and we will warm up to the work, and as our help becomes trained we can fall into line under chosen leaders, and great good will follow.

From another of the most northern States, President W. J. Chamberlain, of the Iowa State Agricultural College, writes:

> I think there should be two general kinds of experiments, one for present or speedy, tangible results to justify the stations to the people, and one for results more remote in time, more scientific, more accurate, and less immediately tangible.

Among the questions of special interest in his State he enumerates: "Hardy fruits for this climate and acclimating them;" "the best modes of saving and applying manures and fertilizers;" "modes of planting and tilling various crops;" "the best varieties of corn, potatoes, oats, etc., for our locality;" adaptability of "celery, onions, and other high-priced (per acre) products to our soil and climate;" "the value of ensilage and other bulky fodders;" "best pasture and meadow grasses for cattle;" "various matters in feeding and dairying;" "best test for buying cream justly;" "best means of getting cream for private dairy and for creamery;" and various problems connected with feeding and dairying.

President Lewis McLouth, of the Agricultural College and director of the experiment station of Dakota, sends a very interesting letter, from which the following are extracts:

> If we can get the aid promised, and which, under Comptroller Durham's decision, is equally applicable to the Territories as to the States, we shall enter upon the work with all our energy. We have 400 acres of good improved land, with buildings, tools, etc.
>
> The following are some of the experiments we are proposing to enter upon:
>
> *Corn.*—To plant a plot of all the quick-growing varieties of corn we can find every day through May, and keep record of date, cultivation, the reaching of several stages of its growth, and of its maturity, for the purpose of helping to settle the question of corn culture for southern Dakota, the corn season, and the kinds to plant. Wheat and flax have been nearly all the crops grown heretofore, until last season, when much corn was planted and matured.
>
> *Grasses.*—We are going to try to identify botanically all the native grasses here, west to the mountains, and enter upon a series of trials to introduce the tame grasses and clovers.
>
> *Vegetables.*—To try growth of sugar beet and many forage roots. To try to find the best tomato for our climate.
>
> *Fruits.*—To find one of our many native plums worth cultivating and improving, and possibly the same for our native grapes. To try gooseberries, dewberries, blackberries, and raspberries. Gather information about the Russian and other hardy apples.
>
> *Forestry, hedges, etc.*—We shall endeavor to extend our knowledge of quick-growing trees for production and fuel and seek for a suitable hedge plant for fences.
>
> *Stock.*—We have small herds of Holstein, Friesian, Hereford, Polled Angus, and Short Horn cattle; Shropshire and Merino sheep; Berkshire, Jersey Red, and Poland China swine; Clydesdale and Percheron horses; and with these we are going to try to find out which are best for our cold climate, our pastures, and forage crops.
>
> *Chemistry.*—We propose to study by analysis our "alkali" lands and waters.
>
> *Meteorology.*—We are going to try to organize a local weather service with view to protection against blizzards (many people were frozen to death last Thursday in one that came in ten minutes and in which the thermometer fell from 30° plus to 30° minus in six or eight hours), and by which we can determine mean temperature, rainfall, etc. We shall test soil temperature as well.
>
> This is in brief outline what we have in mind as most immediately needed here. Our climate is so unlike that of Minnesota, Iowa, or Nebraska that many of these things must be brought out here *de novo*. For example, we have 3 feet of snow with 10 and 12 foot drifts and a mean temperature for the last six days of −24° F., while the mercury has frozen two or three times.

President McLouth adds in conclusion:

> I shall be pleased to get all the aid, information, and advice from the older stations possible, and we shall try here to do our work honestly and thoroughly.

President B. L. Arnold, of the State Agricultural College of Oregon, sends "a few suggestions," saying that others could be made, "but they seem too obvious to need mention:"

> (1) A collection of all well-established principles relating to agriculture should be made and printed for the use of farmers. No doubtful principles should be incor-

porated in such collection, only such as the colleges and stations all receive as true. Farmers do not know what to rely upon with certainty. I think that the farmers might thus be brought to look to the colleges and stations as guides in agricultural principles.

(2) I think it very unwise to publish accounts of experiments for general distribution; people do not generally discriminate between experimental facts and principles. Nothing should go from the colleges to the farmers but well-established principles.

(3) There should be some means by which the experiments of the several colleges and stations can be reduced to system and their value for the establishment of principles estimated.

(4) Such graduates as devote themselves to farming might, perhaps, aid the colleges and stations in the work of experiments.

(5) It seems desirable that there be issued by the colleges and stations from time to time a bulletin exposing frauds in fertilizers, seeds, foods, machinery, etc., and giving notice of anything new and useful to the farmer. In this relation a paper (scientific) representative of all the colleges and stations might be established under scientific editorship.

(6) Oregon has to study: (1) How to render her wheat more nitrogenous; (2) natural sources of fertilizers; (3) forestry; (4) drainage in special relations; (5) how to render her fruit-trees longer-lived; (6) grasses and meadows; (7) the relation of wheat raising to soil exhaustion, etc.

The director of the Connecticut Station, Prof. S. W. Johnson, submits the following:

The Connecticut Agricultural Experiment Station necessarily devotes much of its time to the analysis of commercial fertilizers and the various waste materials which are used as fertilizers. Attention is also given to the examination of feeding stuffs. The study of methods of analysis and examination of soils, fertilizers, feeding stuffs, and other agricultural products has also been a prominent feature in its work. The examination of suspected samples of butter for the State dairy commissioner has been undertaken by the station in order that the law regulating the sale of imitation butter might not become a dead letter.

The definite lines of work which it will follow the coming season, with the aid of funds from the national Treasury, can not now be stated because they have not yet been passed upon by the board of control.

The renovation and maintenance of pasture land, the most economical methods of raising, curing, and using the Indian-corn crop, the possibilities of the sorghum crop in this State, the economy of using undissolved phosphates in place of superphosphates, experiments in feeding, in the rapid and accurate testing of milk or cream delivered at creameries, in the production of butter and cheese, and various horticultural matters, are all promising lines of inquiry in this State.

The director of the New Jersey Station, Prof. G. H. Cook, suggests the following topics as important in that State:

1. Fertilizer control for protection of farmers.
2. Laboratory methods as guides to farm practice.
3. Sorghum:
    - (*a*) Experiments on varieties.
    - (*b*) Fertilizers adapted to it.
    - (*c*) Times of maximum and minimum contents of sugar.
    - (*d*) Its economic manufacture.
    - (*e*) Planting and tillage.
    - (*f*) Effect of frost.
    - (*g*) Preservation of cane.
    - (*h*) Replacing of maize as a farm crop.

4. Fruits:
   (*a*) Growing healthy peaches and peach trees.
   (*b*) Diseases of grapes, grape vines, leaves, and roots.
5. Soils:
   (*a*) Calcareous soils and their relations to cruciferous plants.
   (*b*) Means of changing hygrometric condition.
   (*c*) Relation of carbon or humus to vegetation.
6. Milk:
   (*a*) Production.
   (*b*) Variations from feed and care.
   (*c*) Economical feeding.
7. Cranberries:
   Helps to their successsful growth.
8. Sweet potatoes:
   Investigation of their diseases.

The fertilizer control is exercised by the State station, which has also studied a number of the questions cited and has done much to interest farmers and secure their co-operation through field experiments with fertilizers, carried out under the direction of the station by societies and individual farmers in different places in the State.

Prof. F. D. Chester, of the Delaware College, considers that—

> The work of the stations should be specialized as far as possible, each station having in view the dominant agricultural interest of the State in which it is located. If any station can choose any one question, or limited number of questions, it will accomplish more than by frittering its energies over the whole field of experimental agriculture.

He suggests the desirability of considering, in the annual convention, the needs of the respective stations and the proper distribution of the questions for study. In Delaware "our chief interests are horticultural and our experimental work must lie largely in that line." Among the individual matters demanding attention is the testing of new varieties of fruit for acclimation.

> The subject of plant pathology should be made a special feature of our work. One of the first questions which we shall undertake (and let me urge the co-operation of other stations), is the study of the disease of the peach known as "yellows." We fear that in this section our prided peach-growing interest is destined to rapid decline unless some check can be put upon the wholesale destruction of orchards from this malady. The entire question of the wide-spread deterioration of orchard trees, from one cause or another, is a subject which now demands serious attention. * * * I would also suggest the carrying out of systematic lines of experimentation of truck farming. Fertilizer experiments of the nature of those so frequently made in cereal culture would be most profitable. The same experiments should be extended to small fruits.

Professor Chester makes two further suggestions that are worthy of consideration. One has to do with the securing of the interest of the farmers. For this purpose he recommends that the station officer of the stations meet them at farmers' institutes in different parts of States.

> * * * The work, present and prospective, of the stations could (in this way) be brought directly to the farmer.

His sympathy can often be obtained in this way as in no other. The other suggestion has to do with meetings of the workers of the stations.

Besides the annual convention, in which general matters are discussed, Professor Chester asks:

> Would it not be to the advantage of workers in special lines of research to meet at the same time and place, whether delegates or not, in sections for discussion of matters of purely technical interest ?

President E. M. Turner, of West Virginia University, suggests that experiments on the breeding and feeding of animals and on dairying would constitute the natural work of the station in that State. Connected with this would be experiments on grass as herbage, and for winter feeding as hay, and the kinds of soils that suit them best. He adds:

> I believe a large part of our work ought to consist, for several years, in having experiments made in several localities as object lessons.

At the time of this writing there had been no attempt at organization of a station, and President Turner was of the opinion that it would be best to "hasten slowly, and not to appear too anxious to spend the money that may be placed at our disposal."

The director of the Ohio Agricultural Experiment Station, Prof. C. E. Thorne, writes as follows:

> While the number of questions that press for solution is very great, there are three principal lines of inquiry that seem to me to demand the first attention of the Ohio Station.
>
> Official statistics show that Ohio farmers are paying out nearly $750,000 annually for commercial fertilizers to be used on the wheat crop alone. No one who is familiar with the conditions of agriculture in Ohio can doubt that much of this money is unwisely spent, and here therefore opens a field in which the experiment station may do work that may not only be made immediately available in convincing the farmers of the State that their interests are identical with those of the station, but may also afford the best opportunity for further research into the unsolved problems of soil fertility. I believe that, to accomplish the greatest good, these fertilizer experiments should be carried on—at the central station, at least—in two parallel lines; in both lines fertilizers of definite constitution being applied continuously to the same plots of land. In the one case these plots should be planted continuously to the same crops, and in the other the plots should be cultivated under a judicious rotation of crops.
>
> The production of meat is an industry whose importance ranks next, among Ohio farmers, to that of cereal crops; but in meat production, as well as in cereal production, there is urgent need that greater economy should be studied. That the demands of the market in respect to meat are changing there can be no doubt; the excessively fat meat that brought the highest prices a few years ago is now taking a subordinate position; it is nitrogen, not carbon, that is demanded by our nervous, hard-thinking, hard-working age, and how to furnish this nitrogen in largest quantity and most palatable form is a problem that may well engage the attention of every experiment station in America.
>
> The third line of investigation which seems to me most imperatively demanded in Ohio is horticultural. It has been many years since Ohio has had a full crop of apples. Not only are our old orchards failing through decrepitude, but over a large portion of the State young orchards die before coming to maturity, or fail to bear remunerative crops when mature, and this evil is not confined to Ohio alone. To discover a practicable remedy for this state of affairs would be well worth the expenditure of the entire sum granted to the States for experimentation.

These questions are suggested as specially needing attention in Ohio; but it seems to me that they are of scarcely secondary importance in most of the other States. The conservation of soil fertility especially is a problem towards whose solution only the first steps have been made; it is a problem that concerns every State, and it is one which not only offers special facilities for co-operative work, but in which such work is especially demanded.

The one suggestion I have to make in reference to the general conduct of the stations is that the idea that there is any call, occasion, or excuse for the performance of any work, by any station, that is not thoroughly scientific should be at once and forever dismissed. There can be no greater nor more fatal mistake than the prevalent idea that it is necessary to descend from science to empiricism in order to gain popularity with the farmer. No test of the laboratory can have any truly scientific value unless its results are applicable to the conditions of field and stable, and this application is a work as truly scientific and requires as high an order of ability as that required for success in the laboratory. The one test of scientific work in agricultural experimentation is practicability, and no man more surely applies this test, nor more quickly appreciates its demonstration, than the American farmer.

In speaking of field experiments with fertilizers, Professor Thorne asks: "Ought not those of us who expect to be personally engaged in this work to hold another meeting before spring, in order to more thoroughly discuss the practical side of the question than was possible at the Washington convention."

In a later communication Professor Thorne writes as follows:

The questions requiring investigation by the Ohio Agricultural Experiment Station may be divided into three principal groups, viz: (I) Those relating to the soil; (II) those concerning the growth of crops and vegetation, and (III) those relating to the care and management of domestic animals.

I. The soil should be studied—
  (A) In its varieties, as found in different parts of the farm or State;
  (B) In its physical properties, as affected by drainage, methods of tillage, etc.;
  (C) In its chemical properties, as related to the problem of maintaining fertility.
II. In vegetation some of the objects of study will be—
  (A) Varieties, the problems being—
    (1) Selection and dissemination of improved sorts;
    (2) Establishment of synonyms;
    (3) Comparisons of "strains" of varieties;
    (4) Production of new varieties.
  (B) Methods of culture, embracing—
    (1) Quantity of seed;
    (2) Methods of planting;
    (3) After culture;
    (4) Effect of fertilizers upon quality of produce.
  (C) Vegetable pathology.
  (D) Insect control.
  (E) Forestry, embracing the culture of forest trees—
    (1) For ornament;
    (2) For wind-breaks;
    (3) For timber;
    (4) For nuts and incidental products.
III. In the study of animals some of the problems will be—
  (A) Breeds, and their comparative value for different purposes;
  (B) Foods and feeding—
    (1) For growth;
    (2) For the production of meat;
    (3) For the production of milk.

In addition to the foregoing the station will be expected to perform some general work for the farmers of the State in the identification of plants and insects; in giving information on the control of insect pests and plant and animal diseases; in the testing of seeds, and in suggesting means for the amelioration of refractory soils.

In the execution of this work the studies of the soil and of vegetation will be conducted along the parallel lines of agriculture and horticulture, the experiments being planned, as far as practicable, to elucidate problems in both these lines, yet each should constitute an independent department, with a separate outfit of employés, teams, and implements.

President J. H. Smart, of Purdue University, Indiana, makes the following suggestions:

1. In attempting to co-ordinate the work done by the various stations it is conceded that we ought to know what has been accomplished. It has been also suggested, I think, that we ought also to know what is being accomplished. Should we not, in addition to this, have some means of knowing what is being attempted? If you, for example, are at work on some special line of investigation, is it not possible that others not specially engaged in that line of work might be able to pick up a good deal of information incidentally that would be of use to you?

2. Should there not be a careful indexing of all the valuable literature upon the subjects which will naturally interest investigators connected with experimental stations? And could not a scheme be devised by which the indexing could be done in a very short time, by assigning certain subjects or divisions of the work to certain men? Some of our men would undertake our share of the work at any time.

President Selim H. Peabody, of the University of Illinois, writes:

In many respects the experiment stations will naturally and necessarily be unlike. I think it well that they should be, in no inconsiderable degree. The work, if adapted to the several States where they are situated, will be different. The first point, I suppose, to be settled when a manufactory is to be built, is to determine what is to be manufactured, whether lace, pins, sugar, or horseshoes, and the nature of the product sought will determine the entire line of appliances, even to the motive power of the steam-engine.

We shall not ask how to build and equip a laboratory, because, first, we have one entire floor of a building 75 by 125 feet, with heat, water, gas, and electricity at our command. When we have worked up to that capacity we shall have learned what we want, and how to provide the needful equipment. * * *

We shall probably attack some of these questions, as those which we think will most nearly concern and most especially interest the farmers of our State. I shall not attempt to put them into any order of consequence, for I do not think we have quite determined that for ourselves, except to say that the animal husbandries will take a very prominent place.

(1) Study of the soils of the State; physical properties; chemical constitution; influence of drainage upon both.

(2) Agricultural field experiments. Testing of seeds; testing of varieties; production and improvement of varieties; all circumstances of planting and of fertilization; natural and commercial fertilizers, and the utilization of products now wasted; especially all circumstances influencing the culture of Indian corn; afterwards other grains and grasses.

(3) Cattle feeding. Careful experiments upon varieties of foods; of breeds; of ages for flesh, fat, milk, butter, and cheese. The scope of this work is very broad.

(4) Fruit culture. Important questions are pressing in this field. Our orchards are perishing for lack of moisture, or nutriment, or proper treatment, or all combined. Other fruits, as plums, grapes, small bush fruits, and berries, afford many questions for investigation.

(5) We have made the fungus diseases of plants and bacterial forms of disease in all fields subjects of much study, which will be continued. Diseases of animals may be considered as they arise.

We are particularly situated as to entomology. We have at our university the State laboratory of natural history and the office of the State entomologist. It will not be wise to duplicate this work. We shall take some subjects off his hands, and shall probably turn over to him all the work which strictly belongs in his field.

When we have organized lines of work in some or all of these fields we shall then see how they will of themselves bifurcate, and what others may be added. We propose to begin moderately, carefully, and to move no further nor faster than we can do intelligently.

From Kansas, President George T. Fairchild, of the State Agricultural College, sends the following communication:

According to promise, I now offer a few suggestions, as requested in circulars of October 19 and January 1. A committee of our faculty having agreed upon certain preliminary facts and opinions, we make the following suggestions as to—

I. Mutual aids to successful work:

- (1) General plans of organization, with various modifications, and some detail of division of duty.
- (2) Suggestions as to buildings and apparatus suitable for definite purposes, means of obtaining suitable tools and apparatus.
- (3) A settlement of general nomenclature for certain lines of experiments, with a clear explanation of terms.
- (4) A general scale for experiment, size and shape of plots, size of pens, number of animals, quantities of seed, by weight or measure, etc.
- (5) Selection of experiment, strictly scientific and generally practical, for trial at all stations under definite conditions at the same time.
- (6) Uniformity of tabular statements of similar tests.
- (7) Uniformity in style of bulletin for binding and filing and compiling.
- (8) Settled basis for partial reports of experiments in progress.
- (9) Concerted action in distribution, as to extent of circulation and methods.
- (10) Concert of action as to special information, access to reference books or large libraries, subject indexes, etc.

II. Organization: Our preference here is—

- (1) General control of regents of the college by usual quarterly meetings.
- (2) Special direction by organized council of members of the faculty directly interested, viz, president and professors of agriculture, agricultural chemistry, horticulture and entomology, biology, and domestic economy. This council should have frequent and regular meetings, and the presiding officer should have general executive authority.
- (3) The special work apportioned to separate departments, with careful estimates for equipment, supplies, and assistance. Assistants to be strictly subordinate in duty and position to the several heads.
- (4) Reports of the departments to be to the council, with special settlement of modes of compiling and publication.
- (5) Accounts, to be a distinct department of the books of the college secretary and treasurer, with vouchers audited by the regents quarterly.
- (6) The treasurer of the college to be treasurer also of the experiment fund.

III. Lines of experiments:

- (1) Agriculture proper:
  - (*a*) Selection and development of drought-resisting plants, fodder, grains, and grasses.
  - (*b*) Cultivation (various modes, adapted to climatic conditions over the State) of grasses and clovers for hay, pasture, and soiling.

III. Lines of experiment—Continued.

- (*c*) Results of cutting corn of different varieties at different times or stages of growth, as to value of crop—grain, stalks, and both.
- (*d*) Ensilage, forms of silo, best matter, best methods of filling, best handling. Results of feeding it, for milch cows, growing stock, and full-fed beeves.
- (*e*) Full feeding, cattle and swine, for quality and quantity, gross and net. Kinds of feed: Grain whole or ground for absolute gain and for relative profit. Effects upon digestion of various forms of feed and various treatment.

(2) Agricultural chemistry:

- (*a*) Laboratory tests for sources of plant food.
- (*b*) Effects of combination of plant food.
- (*c*) Investigation of natural sources of ammonia and other plant foods.
- (*d*) Treatment of alkali lands to bring fertility.
- (*e*) Development of the sorghum for increase of crystallizable sugar.
- (*f*) Supplemental analyses in the harvesting, curing, and feeding experiments under agriculture, and for others in horticulture, biology, and domestic science. Credit for such work to be given in the reports of the several experiments, with a summary in the annual reports of the chemical department.

(3) Horticulture and entomology:

- (*a*) Acclimation of plants suited to special climatic conditions of different parts of the State.
- (*b*) Origination of plants for similar ends and careful breeding by selection.
- (*c*) Special modes of culture for resistance to extremes of heat and cold and to drought.
- (*d*) Orchard drainage and sub-irrigation. Orchard manuring, etc.
- (*e*) Lawn culture under special conditions.
- (*f*) Forestry—new sorts and combinations for this climate. Modes of planting and culture.
- (*g*) Economic treatment of injurious insects by mechanical means or poison.
- (*h*) Propagation of natural enemies of injurious insects, parasites, and diseases.

(4) Biology:

- (*a*) Parisitic plants—distinctive forms, culture, destruction, prevention.
- (*b*) Germs of disease in animal life—forms, development, culture, destruction, prevention.

(The exact forms to be studied first have not been decided upon.)

(5) Domestic economy:

- (*a*) Food preparation as to nutriment, economy of materials, and preservation of flavors.
- (*b*) Food preservation—fruits, meats, and vegetables.
- (*c*) Dairying—butter-making, handling milk, temperature, churning and separating waste products; cheese-making, methods in making, curing, and storing; forms, flavor, color, etc.

(These are not all mentioned in the act, but are included by inference.)

In conclusion let me say that I have risked the somewhat full outline above for your scrutiny, hoping that an equal frankness elsewhere may reciprocate to our favor. Many thoughts, even if some of them are crude, can not but result in good to all.

In nearly all of the lines above suggested we have work already in progress and have experienced men at the head of each of these departments, so that we feel ready for full work as soon as means for extension of our plans are available.

A letter from President C. L. Ingersoll, of the State Agricultural College of Colorado, is particularly interesting from the new problems which it suggests. In view of the great size of this State, and the natural division into some five well-defined regions with different demands, its legislature has provided for four sub-stations. These, with the one directly connected with the college to which they are tributary for scientific work performed, make virtually one station for each of the five divisions of the State. For each of these 200 or 240 acres of land has been set apart.

Heretofore the board of agriculture have spent considerable money on experiments from the State fund. It is proposed to use the State fund to enlarge our buildings and equipment and to carry on the school, and the United States (agricultural college land grant) fund for salaries, and the Hatch-bill fund for experiments purely.

The questions that will first demand attention of the station are climate and water control and use in irrigation. The great immediate question is the rain-belt, which some assert is moving westward, and will allow the farmers in the eastern 100 miles of our State to raise good crops without irrigation. We have established meteorological stations at five points outside our college, and obtain the reports from about as many more stations. From their records, as time goes on, we hope to develop something. The great question of irrigation just now is water control and distribution; this is supplemented by "the duty of water." The college has already taken up the latter question.

Further demands upon the station will be to determine the adaptability of grain-grasses, root crops, and other plants which may be grown in that latitude, and the most economical methods of growing such crops without irrigation. "Fertilizers we have but little to do with yet, but we shall move in the matter very soon, as there are two or three manufactories of bone phosphates, gypsum mills, and the like. The acclimation of various fruits, grains, grasses, etc., and their distribution" also calls for experimental inquiry. In addition to the above are a number of questions of interest, such as, "What do rain and irrigation, combined and separately, do for the land by way of fertilization? What shall we do with 'alkali flats?' Does tile drainage promise relief, partial or complete? What crops, if any, can be grown upon such lands before and after improvement? Does the seepage of land constantly irrigated—*i. e.*, for a series of years—perceptibly raise the brooks and streams, and, if so, how much? * * * The great forage crop alfalfa creates a new factor in the feeding problem, which will call for chemical analyses and accurate feeding experiments. * * * Then there are the beet-sugar and sorghum-cane questions for us, especially in Arkansas Valley. * * * Corn has only been introduced and raised in paying crops within the past six years in this part of the State. Now every farmer raises some. It is a great clearing crop for the soil, to get rid of weeds. * * * The field here is an interesting one in which to work, and I shall heartily co-operate as far as I am able."

From Nevada Dr. Le Roy D. Broun, president of the State University and director of the Agricultural Experiment Station, gives the following list of questions as of special interest in that State:

(1) What varieties of apples and cherries are best adapted to central and western Nevada?*

(2) What grasses, besides alfalfa, will do well in Nevada?

(3) What varieties of wheat and other cereals are best suited to Nevada?

(4) Are there any new crops not raised in the western part of the United States that would probably prove to be remunerative in Nevada?

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* We have from 11 to 12 inches annual rain-fall and an average annual temperature of about 51° Fahrenheit; frosts in October and early part of May.

Dr. H. B. Battle, director of the North Carolina Agricultural Experiment Station, after premising that the enterprise is intended to benefit agriculture and the farming class as a whole, and that in each State the work should be such as will advance the interests of the agricultural class in that State, and must therefore be varied to meet the needs of the different sections, says:

> As a rule, especially in the cotton States, these needs, in my opinion, can best be filled by an influence educating in its character—by teaching the people the knowledge they most lack in the proper conduct of their farming operations.
>
> This can be done by disseminating information obtained best by work in the different States (for results obtained in this way will have more weight with the people) and through information from any other source, if this can not be done.
>
> This work should include that which would prove the most practical, and give the most immediate relief, as far as possible, to the farming class. This opinion, as given in the last sentence, is shared by a number of our representative farmers in various portions of the State with whom I have corresponded on the subject, and I have every reason to believe that it is held by all of our people.
>
> It is not my idea that the purely scientific work, which would not bring quick returns, should be excluded, but that it should at present—until the masses are ready to digest them—be subordinate to that more practical in character.
>
> With this preface the following plan for experimental work more especially adapted to this State will be better understood:
>
> (1) The effect of fertilizers on various soils and crops, carried on in conjunction with the experiment station by individual farmers throughout the State.
>
> With such diversity of soil and climate as this State posesses this is a necessity to obtain results of value.
>
> (2) The best system for rotation of crops and the effect of the time of planting of each.
>
> (3) The best treatment of worn-out lands to render them productive.
>
> (4) A study of the cultivation of the staple crops, looking to the improvement of the present system.
>
> (5) The utilization of waste farm products in the manufacture of fertilizers and composts and the examination of the natural products for the same object.
>
> (6) Investigation as to the growth of crops other than those now planted, to ascertain if more valuable crops might be substituted, in part or in whole, for those we now have. Such investigations might include, among others, the study of sorghum, as to the best practical plan for planting, gathering, expressing, and utilizing the juice; the growth of root crops; the growth of plants yielding fiber, such as ramie and jute, and the best plan for preserving the fiber; a study of the various grasses of value, to ascertain how far the raising of hay can supersede the planting of cotton and other staple crops so exhausting to the soil.
>
> (7) Experiments relative to the feeding value of various forage crops grown in this locality, also of the grasses now grown or supposed to be grown in this State, and to instruct our farmers in the value of the various hays and grasses, of the nutritive value of each, and to determine, from the analysis of the plants grown in this latitude, the proper ration for breed and fattening cattle.
>
> (8) The construction of the silo, the preservation of green forage crops as ensilage, and the comparative merits of the latter and forage in the dry state.
>
> (9) Digestion experiments with milch cows, and the amount of milk obtained, with the chemical analysis of the same. Also digestive experiments with other stock.
>
> (10) A study of the temperature of the soil, to ascertain how far it affects the growth of the crops.
>
> (11) Meteorological observations in conjunction with the various work carried on in other lines of investigation.

(12) Investigation of the chemical constituents of the standard crops in the various stages of their growth—of cotton, corn, and tobacco; and the growth of the roots of these crops as determined by root-washing.

A few of these have been partially carried on during the past few years and are now in progress.

The list might be largely increased; for the subject is an immense one, and fruitful with possibilities for good in every section throughout our State. I have merely given these experiments as types of the work which, in my opinion, should be undertaken.

From Alabama two replies have been received, one from President Le Roy F. Broun, of the Alabama Polytechnic Institute and Agricultural and Mechanical College, and one from Prof. J. S. Newman, of the experiment station connected with that institution. President Broun writes that—

With us the questions that demand the most attention are, to restore and maintain the fertility of the soil, and do this with profit to the farmers and economy of animal feeding.

Among the minor questions are those of ensilage and cotton seed as an article of food. Professor Newman says:

In the organization of the stations there should be a thorough classification of work to be done, and specialists should be placed in charge of each division. * * *

The work should be classified as investigative and demonstrative; the first to discover truth; the second to prove that already discovered but not generally recognized. This classification should apply to each division. These divisions should embrace botany, entomology, and ornithology, microscopy, chemistry, animal industry, pomology, etc., corresponding roughly with the divisions of the United States Department of Agriculture, with which close relationship should exist.

There should be provision made by which the director could either go or send a chief of a division to any part of the State for the purpose of collecting or imparting information. We can never educate the people up to a correct conception of the proper work of a station without more or less personal contact with them.

Co-ordination of work, except in the investigation of general laws, will not be practicable unless isothermal lines are roughly followed in arranging the concurrent work.

Mr. S. W. Tracy, recently appointed director of the Mississippi Agricultural Experiment Station, in connection with the Agricultural and Mechanical College in that State, writes:

Among the questions of most importance to us in the South are:

(A) What is the best ration for milk and for beef—cotton seed to be a leading component?

(B) What can be mixed with cotton seed in feeding milch cows to prevent the "tallowy" texture of the butter which follows a too free use of the cotton seed?

(C) To what extent can the silo be made profitable south of 35°?

(D) What is the best method for renovating the worn-out and unproductive cotton lands?

(E) What is our best crop rotation, cotton to be grown once in three years.

There are two points upon which I think it very desirable that station managers should agree, viz: What is the best size for experimental plots, and how far must such plots be separated in fertilizer and other similar tests? Also, in observing soil temperature, at what depth should the thermometer be placed?

Among the questions of general interest are:

To what extent should the station be used for making field tests of commercial fertilizers?

To what extent should the station take part in the farmers' institutes, fairs, and similar work?

Will it be better to publish small monthly or quarterly reports, or more complete annual reports? My own preference would be for the latter plan.

It is of great importance for us to have information of what has already been accomplished at other stations, but of course we can not all secure full sets of reports. Would it not be a legitimate expense for the stations to unite in the employment of some one to collate, abstract, and publish the results accomplished up to the present time? Might we not induce the Department of Agriculture to do this?

Prof. Albert E. Menke, director of the Arkansas Agricultural Experiment Station at the Arkansas Industrial University, writes:

The farmers in the central and southern portions of this State are interested chiefly in cotton; those in the northwestern part, in fruit and stock. There is some stock-raising in the southwest, but not much outside of a few counties. I intend to have work done in the three sections, as the climate, etc., varies considerably.

Prof. George W. Curtis, of the Texas Agricultural and Mechanical College, reports a number of questions as calling for study in that State. Among these are–

Soil studies, including tile-drainage, absorption and retaining of ammonia by our sub-clays, etc.

Experiments with fertilizers of all kinds.

Experiments to test, through a long time, the loss and injury to soil by grazing.

Feeding experiments to decide the value of foods, cooked and uncooked; of cotton-seed and cotton-seed meal, and the best way of preparing cotton-seed for feeding; and of other fodder products, native and purchased.

Testing varieties of cereals, grasses, cotton, ramie, jute, etc.

Sorghum for fodder and for sugar.

Acclimating (or Texas) fever.

Professor Curtis urges the need of a "central station at Washington which should condense from and compare bulletins and edit and publish an annual bulletin for free distribution."

COMMENTS, RECOMMENDATIONS, CONCLUSIONS.

The perusal of these letters, supplemented by personal conversation and correspondence with gentlemen interested, leaves several quite clear impressions. One is, that neither the questions to be studied nor the methods for their investigation are definitely decided upon in most cases. This could not well be otherwise at a time when even the funds for the work have not been positively assured by Congress, and but a small number of stations are actually organized. Doubtless many of the gentlemen to whom the circular of inquiry was addressed will sympathize with one of them, a college president, who, in writing of questions for investigation, says: "I have had no time to bestow thought upon the subject." Indeed, it would be difficult for the director of any station to say in advance just what his work was to be, unless previous experiments had led it into very definite and special lines. Except in a few cases, where stations have been established for some time, the enterprise is in its formative stage. The character of the work is to be developed. But these statements, incomplete as they are, are the first step toward that mutual understanding which will be most helpful for the advantageous planning and co-ordination of the work.

Another impression is that, with the diversity of conditions under which the work of the stations is to be done, there is a notable unanimity of opinion with reference to its general character and spirit. It is felt that the work must be truly scientific and truly practical, that the questions which are of the most interest to the farmer must be selected, and that they must be studied in the light of the most advanced knowledge. The views regarding details are diverse, as would be expected. There is a quite general call for condensed statement of what is being done by the stations and a number wish to know specifically in advance what the others are proposing to do. The desire for compilation of methods and results of work already done in this direction in this country, and especially in Europe, is earnestly, though less frequently, expressed, and those who are most familiar with that work are the ones who lay the most stress on its being made available to our workers, in order that they may avoid useless repetition of work already done and avail themselves of what is known as to what is most needed to be done and how to do it.

There is the solicitude lest the inevitable crudeness of the enterprise in its early beginnings may involve waste of energy and money, disappointment to its promoters, and future loss of support. But over against this are the earnest desire to do what is best, the alertness in seeking information, the readiness to use the aids that can and ought to be made available, and the American facility for grasping new ideas and accomplishing what needs to be done.

While the interest of some of the topics is confined to individual localities, and while some of those which extend over broad areas are so affected by local circumstances that the results obtained in one case may not apply in another; yet, on the other hand, many of the questions, including the most important ones, cover wide areas, or the whole country, and are everywhere more or less nearly the same. Strictly co-operative research is not in all cases either feasible or desirable; indeed, the major part of the work of the stations will be best done in accordance with the enlightened plans of individual specialists. There are, however, lines in which union of plan and effort will increase the value of results while diminishing both the cost and the time of production.

Among the matters of importance in this connection, there is one which, in the judgment of the committee, demands particular consideration. It is the need of means for making the results of accumulated experience conveniently available to the stations and their workers. In entering upon the study of a given problem it is essential to know not only what has already been found out, but in what direction further inquiry can best be prosecuted and what experience has to say as to the ways and means. This is, at the bottom, merely the assertion of the obvious principle, that the first condition of successful research is full knowledge of what has been done.

Some of the problems proposed for study, especially those in the newer stations and territories, are comparatively new, but the majority are of essentially the same kinds that have been engaging the attention of experimenters for many years. Such are those connected with the chemistry and physics of the atmosphere and soil; the exhaustion of the soil and the restoration of its fertility by tillage and manures; the composition of plants and their adaptation to different localities and conditions; the feeding of animals, the production of milk, butter, and cheese, and other matters connected with the dairy; the diseases of plants and animals, fruit culture, and numerous other subjects. To one familiar with the history of this sort of research it is interesting to note how many of the problems suggested for study by the different stations are nearly or quite identical with those with which work of the experiment stations was begun when the first ones were founded over thirty years ago, and how large a proportion are in fact the same that have been the object of the bulk of the study of these and other institutions of research in this country, in England, and to a far larger extent on the continent of Europe, for half a century.

A large number of the stations will necessarily labor under the disadvantage of inexperience. In other countries the growth of experiment stations has been gradual, and new ones have been established no faster than skilled experts were ready to man them; but in this country the enterprise is being enlarged suddenly and to an extent previously unheard of. The difficulties which the newer stations have to meet from this source are enhanced by the fact that nearly all of the accumulated experience is recorded in foreign literature, and accessible only to those who have at hand the great accumulation of journals and other publications in which the results of earlier and later research are set forth.

The committee are strongly of the opinion that one of the most useful services to the cause would consist in the compilation of the main results of this research in various special lines and the putting of them not only into English but in forms conveniently suited to the use of the American investigators. This service would be appreciated as warmly by those who have long endeavored to follow up the literature and are constantly and painfully reminded of their inability to keep themselves well posted in its details as by those who have paid less attention to them.

Although the first agricultural experiment station was established about thirty-five years ago, the number of European experiment stations and other institutions in which experimental research of interest to agriculture is being actively carried on is not now very far from one hundred. The natural outgrowth of this large amount of research has been the collating of results in various journals, memoirs, and other publications. One of these is the "*Jahresbericht der Agrikultur-Chemie*," a yearly record of work in agricultural chemistry and kindred branches of science. This was begun in the year 1858, and the volume for that year has 258 pages. The twenty-ninth volume, that of 1886, has 638 pages. This increase in size is very far from measuring the increase in the amount of work per year during that period, since in the later volumes the reports of investigations are much condensed, and many are of necessity referred to only by title. This work is edited by Professor Hilger, of the University of Erlangen, and ten associates, who are able, by dividing up the current literature between them, to make brief abstracts of the more important investigations which are continually appearing. The table of contents of the volume for 1886 fills 32 octavo pages and includes 1,215 titles, each the subject of an investigation of one kind or another. The subdivision of topics and the number of titles under each are as follows:

Soil	47
Water	39
Atmosphere	20
The plant:	
Ash analyses	7
Vegetation, seeds, germination, assimilation, metabolism, nutrition	61

Plant culture:	
Grains, potatoes, roots, fodder plants, weeds, etc	86
Diseases due to animal and vegetable parasites and other causes	114
Manures:	
Preparation, analyses, effect in field, and other experiments	56
Vegetable chemistry:	
Compounds found in plants	218
Methods of agricultural chemical investigation	17
Animal production:	
Feeding stuffs: analyses, conservation, preparation, including ensilage, etc.	246
Animal chemistry: Compounds found in organs, tissues, secretions, etc	131
Experimental investigations in chemical physiology	52
Metabolism, nutrition, feeding and care of domestic animals	65
Bee, fish, and silk-worm culture	30
Dairying:	
Milk, butter, and cheese	66
Total	1,215

The number of titles in these several subdivisions, however, does not accurately indicate the relative amount of importance of the investigation in each of the general subjects. For instance, an experiment or series of experiments upon a given question on the feeding of animals may occupy three or four men for six months and be reported under one title, while a half dozen other investigations, which together would cost only a fraction of the labor, would be reported under as many heads; or a single investigation might include analyses of a number of different species of plants, and the results obtained from each species would be indexed by itself. But the volume, as a whole, does give an idea of the range and character of current investigation during the year 1886 in the lines reported upon. Of course this year-book of agricultural chemistry does not cover the whole field of agricultural science, and there are some important subjects germane to the work of experiment stations even in chemistry and allied sciences which it touches upon only lightly, as they are included in other works. Such other compends are the *Jahresbericht der Thier-Chemie*, which is confined exclusively to physiological chemistry, and the *Vierteljahresschrift der Chemie der Nahrungs und Genussmittel*, which is devoted to the food of man, and other like publications.

The specialization of research is already leading to the compilation of monographs on particular subjects, in which the methods and results of investigations up to the time of publication are summarized. One of the most important of these is the volume by Professor Wolff, *Die Ernährung der landwirtschaftlichen Nutzthiere*, which gives a résumé of the work on the feeding of domestic animals. Being written by one of the most prominent of modern agricultural experimenters, and one who has devoted himself for years to work in this especial field, this compilation, which makes a work of considerable size, is, of course, extremely valuable. Another monograph, and one of a different character, is by Baron von Bretfeld, entitled *Das Versuchswesen auf dem*

Gebiete der Pflanzenphysiologie mit Bezug auf die Landwirthschaft. This volume of 264 octavo pages is devoted to the subject of experiments on the growth and nutrition of plants with reference to their agricultural production, and for this purpose gives a brief résumé of the present status of knowledge of the several topics treated, descriptions of the methods and apparatus used in experimenting, and discussions of their relative advantages for their purposes. Germination, respiration, assimilation, and evaporation of water by plants occupy 108 pages, and the nutrition of plants 144 pages. References are given to the original memoirs and other accounts from which the facts are gathered. This work renders to German experimenters a service which, if done for those of our own workers who are to be engaged in investigations in this line, would be in the highest degree helpful.

Before our experiment stations shall have been in operation as long as those on the other side of the Atlantic, it is to be hoped that abundant helps of these and other needed kinds of their work will have been provided. The object of the committee in referring to the matter now is to urge that some provision of this kind should be made at the earliest practical moment. This service has been done for foreign experimenters in their own language, by their own men, and in the forms best adapted to their use. They were not made for us, and are not what we want; though, of course, until we have something better, it behooves us to make the best use we can of them.

It is to be remembered that the work which these treatises tell of is the product of the union of science with experience; that the men who have carried it on have been chosen mediators between practical farming and scientific research; that while the experiment stations have been under the more or less direct control of the farmers, and have busied themselves with the questions with which the farmers were most immediately and intensely interested, they have at the same time been in intimate relations with specialists in the different departments of knowledge, and have had the constant guidance and help of the most successful investigators.

For instance, the experiment stations of the Central Agricultural Association of the province of Saxony, in Prussia, is located in the city of Halle, and its director is professor in the university there. What the farmers want he finds from their constant demands upon the station. To supply these wants, he has a laboratory built especially for the station, ample appliances, trained assistants, access to the university and other libraries, and what is as helpful as any other one thing, if not more so, daily contact with leading specialists. If he wants information about any particular point in organic or technical chemistry, physics, physiology, anatomy, botany, or geology, he does not have to spend days in hunting for it, but may in a few minutes get the result of the years of study in that specialty by conversation with a colleague whom he can meet at any time. Indeed, many such men who are not working in experiment stations at all are nevertheless continually engaged in the discovery of the natural laws which make up the foundation of agricultural science. It would be strange if the decades of work under such auspices in scores of places had not brought forth fruit of great value; and now that so many experiment stations are entering upon the service of agriculture in our own country, and are called upon to grapple with questions which are to a large extent the same, or closely allied to those which have been thus studied elsewhere, it would be a grievous error to fail to utilize that fruit.

The first question, of course, is, how shall we avail ourselves of this accumulated experience? Men who are confronted with all of the details incident to planning and carrying out work of this kind can not spend time to go through the literature of the subjects with which they have to deal and cull out the results they need. Something ought to be done to meet this demand. The committee believe a most useful service to the enterprise would consist in the preparation of monographs, which should embody not only the results of investigations but descriptions of apparatus and methods of research. The task would, of course, be difficult, and would require the co-operation of numerous specialists.

It has been suggested that perhaps a way might be made clear for the Agricultural Department to assist in this matter, or that the stations themselves might combine for the purpose. Possibly an occasional prize offered for a treatise upon a given subject might stimulate capable men to authorship, and thus bring forward talent which would otherwise be slow in coming to notice. If a beginning were made, and the spirit and direction of the enterprise were of the right sort, a series of volumes might gradually be produced, the value of which would be far in excess of the cost. The topics to be treated would be numerous, and the selection would depend upon a variety of circumstances. Among the rest might be such as follows:

(1) Experiment stations, American, and especially European, their history, organization, equipment, management, method of work, etc.

(2) The soil, its chemical and physical properties, and their methods of studying them.

(3) Experimenting upon the growth and nutrition of plants, including the use of fertilizers.

(4) Sugar production from cane, sorghum, and beet.

(5) Diseases of plants.

(6) Composition and nutritive value of feeding stuffs.

(7) Ensilage.

(8) Effect of fodder upon milk production.

(9) Making of butter and cheese.

This is not the place to propose the details of a scheme of this kind, but the committee make the suggestion, believing it to be both useful and feasible.

Through the communications from representatives of the stations above cited there runs the evident conviction of the importance of doing the kind of work which shall be most directly useful to the farmer. The continued support of the stations will depend upon their success not only in meeting the wants of the agricultural public, but making that public feel that they do so.

With reference to this matter the committee venture two suggestions. One has already been urged. It is that a part of the duty of the stations is to teach, but to teach only well-attested and useful facts. By publishing information in terse, simple language, with appropriate explanations, by attending farmers' meetings, and demonstrating in lectures and otherwise the things that farmers need and desire to know, by interesting farmers in experimental work, and securing their co-operation in carrying it out. In short, by diligent effort to carry knowledge to the farmer and help him with it, and at the same time help him to help himself, the workers in the stations will both do their duty and secure the support they need. Such is the experience of experiment stations and agricultural colleges. There is more than one of our most successful institutions which would not be in existence to-day if it had not done a deal of faithful work of this sort.

The other is that, while the stations are under obligations to select for study the questions of immediate practical interest, yet oftentimes those which on the surface appear theoretical are at the bottom the most practical. The seemingly simplest and most pressing problems reach down to the profoundest depths of abstract law, and not infrequently the practical interests of the farmer require the theoretical problems to be considered first, for the same reason that the foundations of a house and not the wall is the first to be built.

Doubtless it is well that the new stations should go through more or less of the same experience that the older ones have, in commencing with concrete practical questions and gradually working toward the study of the laws that underlie them. This will involve loss of time, energy, and money, in the sense that oftentimes the main result of an experiment will be to show the need of studying a problem that lies beneath it. But this will not be an entire loss, for such experiments often bring valuable information even if the goal is not reached, and they are means of showing the constituency of the stations the need of abstract research. Indeed positive good in many ways comes from just such work and experience. The wisdom consists in insuring the minimum of waste.

It is important to know what fertilizers will be most profitable in New Jersey or in Ohio; what forage plants will best withstand the colds of New Hampshire and Dakota; what fruits may be successfully grown in Iowa and Delaware; how cotton seed may be advantageously composted in Alabama or fed to stock in Mississippi or Texas. These are local questions, and will be solved mainly by practical tests made and interpreted in the light of the best knowledge.

It will help farmers to know what are the most economical rations wherever cattle are fed and the best ways of making butter and cheese wherever there is dairying. These questions involve more of general laws and are less affected by local conditions.

But whether a given problem is influenced more or less by local circumstances, it is always controlled by general law. The action of fertilizers depends upon the chemistry and physics of the soil and the physiology of the plant; the making of butter upon the chemical and physical properties of milk; the production of meat and milk upon laws of nutrition; and all these properties and laws are still very imperfectly understood.

Unquestionably the stations ought to make practical experiments in the study of the problems before them. But on the long run, those stations will do best that plan their work most philosophically, and the prosperity of the enterprise as a whole will be proportioned to its success in the discovering of the laws that underlie the right practice of agriculture.

Regarding the scientific policy of the stations there are two important facts to be taken into consideration. One is that ours is a time of general reaching out after what is best. Later years have witnessed a notable elevation of public taste. The spread of popular science and the growth of the higher institutions of learning are evidences of this. It is a matter of common experience among those who are in the advance lines of scientific, literary, and educational progress that the best success is built upon faith in the aspirations of the people at large for something better than they have. If other striking proof of this principle is needed it may be found in our periodical literature. The magazines that have the largest circulation are the ones which have the least of trash and ballast and the most of what is good sound information and ministers to the higher taste. The head of one of the largest bureaus for supplying the newspapers with material for their columns lately remarked that the secret of his success was in furnishing articles a little above the ordinarily accepted standard of public taste.

The other is that the American farmer, although not a scientific specialist, has a keen sense of what is sound and good, and even if he does not understand the details or the exact drift of research, if he has faith in the man who is carrying it on he has faith enough in the thing itself to be glad to have it done.

Although the public taste and the demands of the farmer are not capable of quantitative measurement, they are important factors in the decision of what ought to be the character of the work of the stations. If there is danger of wasting ammunition by "firing over people's heads," there is no less danger of wasting energy and losing their confidence by failing to come up to their ideals.

The station is the servant of the farmer. It is, likewise, his teacher. It will have his respect and his support in proportion as it shows itself worthy by doing the highest work.

As regards the co-ordinating of the work of the stations, the committee do not feel warranted in making many specific recommendations. The plans are still inchoate, and even if the problems were in all cases decided upon, it would be unwise for any man or body of men to attempt to dictate as to how individual work should be carried on. The success of research always depends upon the exercise of the individuality, as well as the ability, of the men engaged in it. Freedom of action is one of its first conditions. Nevertheless, as the work develops, it is evident that there will be ways in which stations can advantageously unite in the study of specific questions. Stations that are to work in dairying may well consult together and seek the counsel of specialists in their selection of questions and the methods for their study. The same will apply to those who are interested in experiments in feeding, fertilizing, and so on through the list of the more general subjects of inquiry.

The committee venture, however, to specify two directions in which, in their opinion, co-operation may be attempted, immediately or very soon, and with promise of success.

One of these has to do with fertilizer control. In a considerable number of States in which the use of commercial fertilizers has already become quite extensive an attempt is being made to exercise control over the quality and sale by legislation, inspection, and analysis. The details of the legislative enactments and the methods of inspection are widely different in different States. The result is inconvenience and loss to both dealers and consumers. Furthermore, the analysis of fertilizers as now carried on in a number of States involves a great deal of labor, a part of which might properly be saved by proper co-operation between the stations in neighboring States. The Association of Official Agricultural Chemists has already done much toward the unification of methods of analyses. But the stations, working through the association of colleges and experiment stations, might exercise a wider and more effective influence toward the unifying of legislation and methods of inspection and the economizing of labor and expense of analysis.

The other concerns field experiments with fertilizers. In a number of the older States experiments of this sort have been carried on during a number of years past. Experience here, as in Europe, where similar enterprises have been instituted by experiment stations, has brought out both the difficulties and the advantages of work of this sort, and has shown that while it sometimes results in failure, yet, on the whole, much good comes from it, especially when the work is done by associations or individual farmers under the direction of the stations. The experiments both serve as object lessons and as means of securing co-operation and the support of the agricultural public and of farmers. When they are carried out on a common plan, but under diverse conditions of locality, soil, culture, and crop, they bring information of scientific as well as practical value.

There is the demand that something be done at once. Among the things that can be undertaken immediately, at comparatively little cost and with the prospect of benefit to both the farmer and the station, the committee are aware of none which promise more immediate usefulness in the older States than this. Several stations have signified their intention to undertake such work the coming season. The committee have already begun correspondence, and if the demand appears they will be glad to do all in their power to assist.

There is still another matter concerning which earnest convictions have been expressed, and which seems to the committee of so great importance that they can not refrain from referring to it before concluding. It is that all due economy should be exercised in the use of the funds to be provided by Congress. At the outset there may be a temptation to spend the whole appropriation, even if the ways for making the best use of it are not perfectly clear. It will be a wiser as well as a worthier policy, and one far better for the cause, to forego the purchase of a little apparatus and to submit to a little delay in the beginning of a given piece of work and let the funds be covered back into the United States Treasury, than to use them for materials not absolutely needed or work which will not be well done.

If the above does not include all that the members of the association have looked for in what the committee were requested to furnish for publication with the proceedings of the Washington meeting, the committee beg them to consider that the plans are still immature—even the appropriation is not made at the date of this writing; that specific recommendations are at the best difficult to make; and that this report has been prepared by men crowded with other occupations and in the busy season of the year. The main points presented may be recapitulated in a few words.

(1) The diversity of conditions under which the individual stations must be organized and conducted renders recommendations as to buildings, apparatus, and other material equipment difficult. A list of books appropriate to a station library has been prepared by one of the members of the committee and is printed elsewhere. The committee will be glad to render any assistance, in response to individual inquiries, which their time and ability may permit.

(2) In view of the action already taken by conventions of representatives of colleges and stations as to intercommunication between stations and the authority given to the Department of Agriculture by the act of Congress, the committee have hesitated to make recommendations. They have, however, ventured to suggest the desirability of an organ of the stations; a publication which should contain accounts of research here,

abstracts of like work in other countries, and other matters of mutual interest.

(3) To obtain information as to the special questions which will demand attention in different localities the committee have addressed inquiries to representatives of the stations. Not all have replied, and among the answers received not a few are more or less indefinite. This is very natural in view of the fact that plans are still immature. The substance of the replies received is given above.

(4) As regards co-ordination of work, the committee feel that the time is hardly ripe for recommendations, and that the most effective and useful co-ordination and co-operation will come from mutual consultation. They believe that as the plans are developed it will become possible to arrange for the study of questions of general interest in ways which will be to a greater or less extent co-operative and thus more efficient. They have, however, ventured suggestions for co-operation in two lines, fertilizer control and field experiments with fertilizers.

(5) In consideration of the newness of the enterprise in this country, the large amount of experience which has come from the work of several decades past in experiment stations and other institutions for research in this country and in Europe, and the importance of making this available for workers in our stations, the committee have suggested the preparation of monographs upon special subjects.

(6) As regards the general character of the work of the stations the committee believe that they will be sustained in proportion as they help the cause they are intended to serve. It is essential that they recognize the immediate demand for things immediately useful; that they find what questions are of direct practical importance, and give such questions an amount of early attention which under other circumstances might be disproportionate. But it is vitally important that the highest scientific ideal be maintained and every effort be made toward its realization. The future usefulness of the stations will depend upon what they discover of permanent value, and this must come largely from the most abstract and profound research; to forget this will be fatal.

The stations must also remember that it is their office not only to experiment, but to teach; that it is their duty to gather information as well from accumulated stores as from the fields in which they are working, and to bring it, not "down to the farmer," but home to him. By thus using their most honest and earnest effort to help the farmer they will secure from him and from the public at large the support they need for their highest work.

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